

Principles and Protocols Neuro MRI

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Neuro Protocols

Objective

- Understand how the array of available MR “tools” is organized into protocols for imaging disorders of the CNS.

Basic Principles

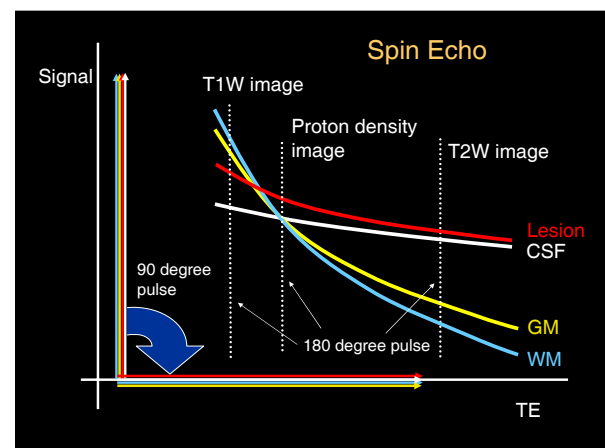
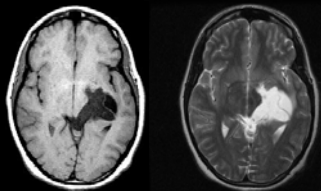
- Multiple planes
 - Sagittal
 - Axial
- MR information
 - T1
 - T2
- Adequate for majority of patients and diseases

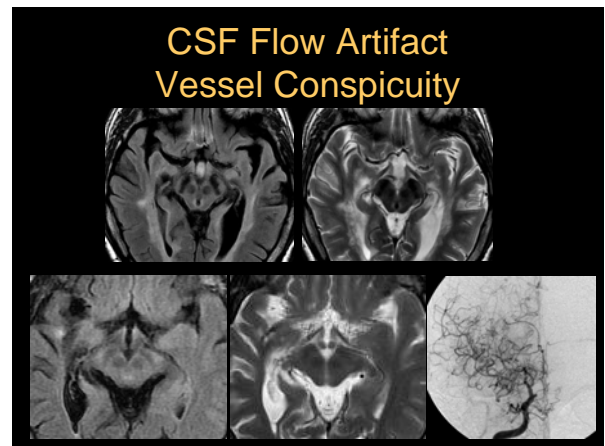
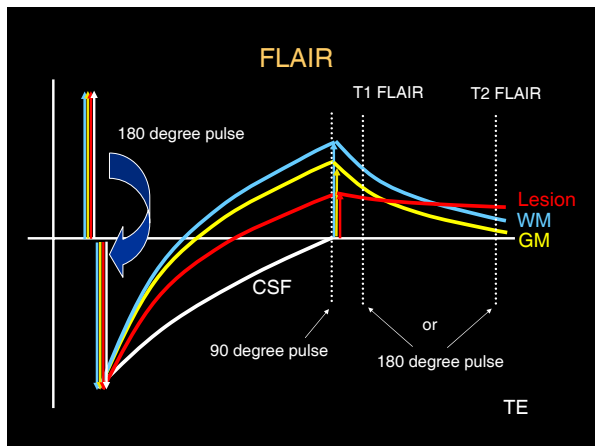
MR Improvements

- New or modified sequences to better visualize or detect pathology
- Function/physiology
- Image faster

Basic Principles

- In general CNS lesions have increased water content and therefore behave like CSF
 - Long T1
 - Long T2

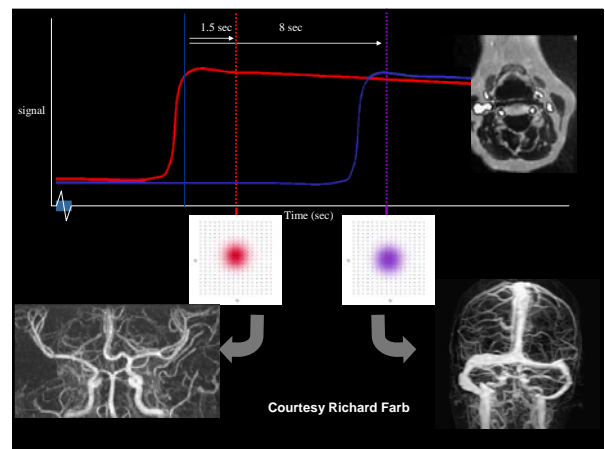
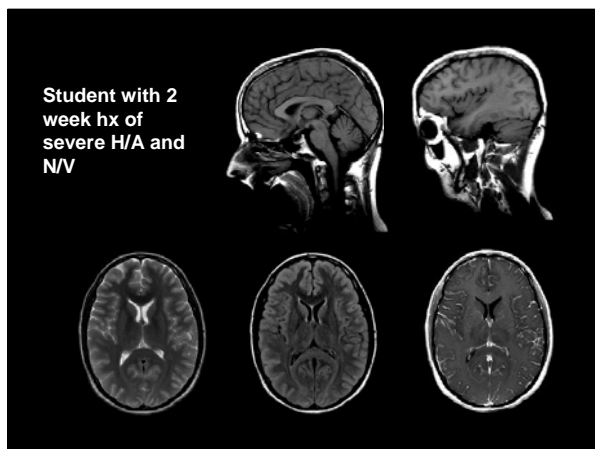
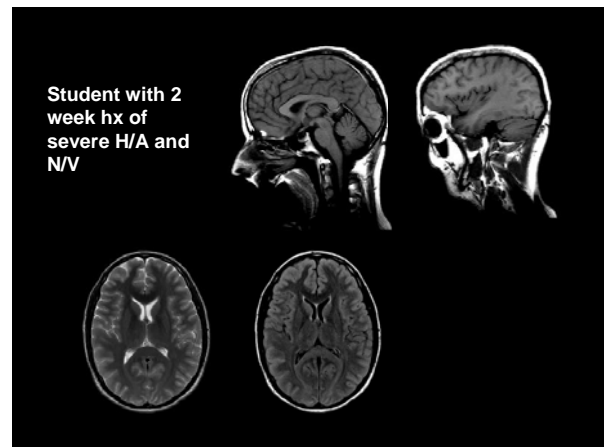




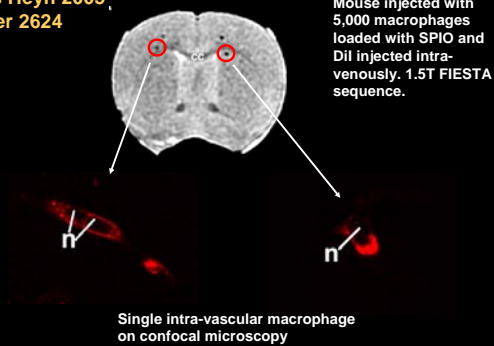
Contrast Agents

- Gadolinium
 - BBB assessment
 - Enhancement pattern
 - Permeability
 - MRA
 - CE-MRA (Gd bolus)
- Molecular Imaging
 - Novel “smart” contrast agents

www.chem.tue.nl/smo/MBE/Dendritic_Contrast_Ag...



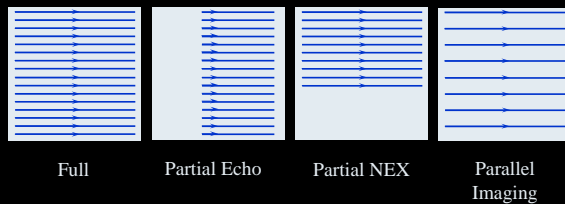
**Molecular Imaging:
Chris Heyn 2005
Poster 2624**



MRI Innovations

- EPI
 - DWI
 - Perfusion
 - fMRI
- Fast spin echo
 - Speed up T2
- MRS
- Parallel imaging
 - Speed

Options for Saving Scan Time



Parallel Imaging

- Hardware
 - Generate images using signal acquired simultaneously from multiple surface coils
- Software
 - Use information in the spatial sensitivity profiles of **multiple receive coil elements** to “unfold” image data
 - ASSET, SENSE, iPAT

ASSET Advantages

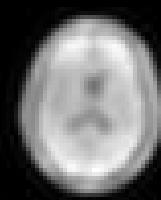
- Decreased scan time
- Increased resolution for same scan time
- “Cleaner” images
 - Sampling fewer echoes to generate image
 - Decreased image blurring
 - Less T2 decay across sampling of k-space (fewer echoes needed)
 - Sharper FSE images
 - Decreased image distortion on EPI
 - Decreased phase accumulation from off resonant spins
 - Decreased geometric distortion in areas where magnetic field is inhomogeneous (skull base)
 - Better visualization of temporal lobes and posterior fossa on diffusion imaging

ASSET Disadvantages

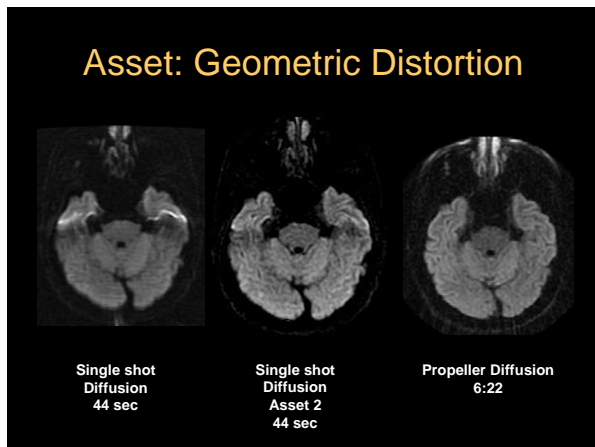
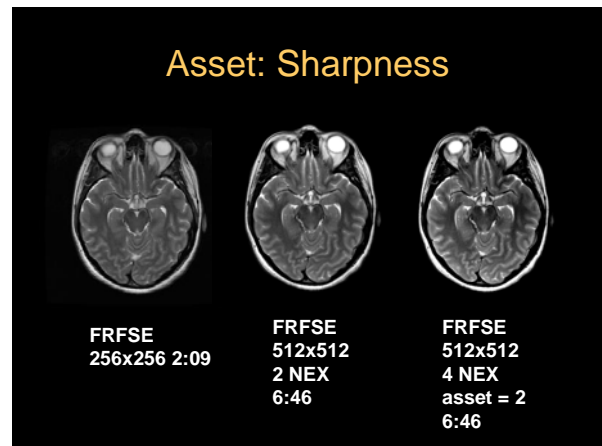
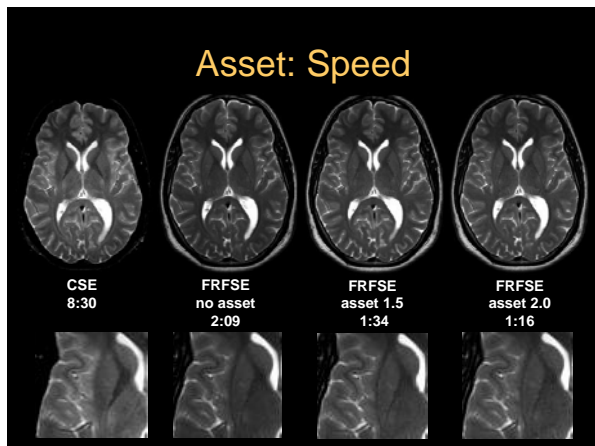
- Increased noise
- Calibration image
- Artifacts
 - uncorrected aliasing

$$SNR_{ASSET} = \frac{SNR_{NORMAL}}{g\sqrt{R}}$$

R = scan time reduction factor
g = geometric factor



11 sec scan



Screening Brain Protocol

- Foundation for brain imaging
- Modify using "palette" to create disease specific protocols

MRS

T2

T1

DWI

T2*

Screening Brain Protocol

- Sagittal T1
- Axial T2
- Axial T2 FLAIR
- Axial EPI gradient echo
- Axial diffusion

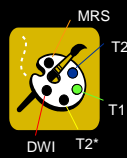
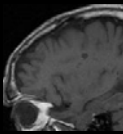
Disease Specific Protocols

- Demyelination
- Tumor
- Epilepsy
- Vessels
 - Arteries (arch to COW)
 - Aneurysm
 - Sinovenous
- Infarct

Demyelination

- Requirements:

- Plaque detection
 - T1
 - T2 and proton density
- Gd for Rx response



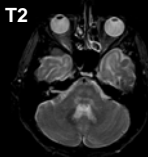
Flair



PD

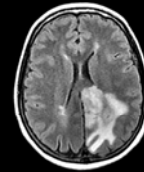
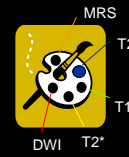


T2



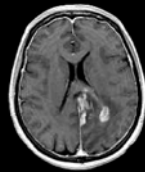
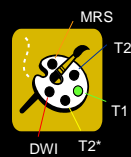
Tumor

- Clinical
 - T1 post Gd
- Tissue characterization
 - MRS
 - Permeability
- Surgical Planning
 - fMRI
 - DTI



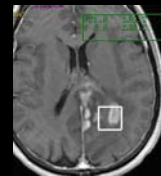
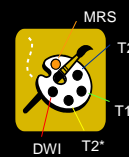
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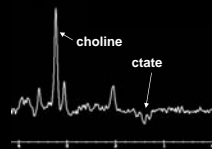
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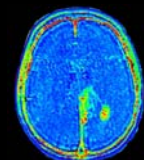
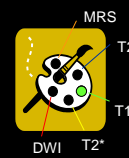
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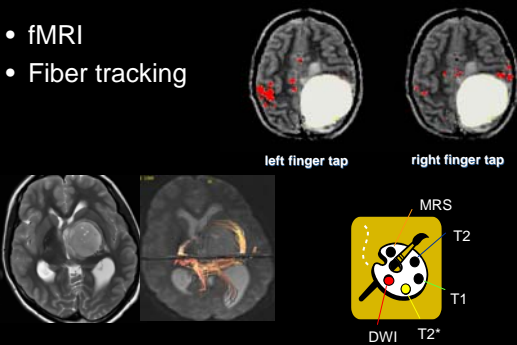
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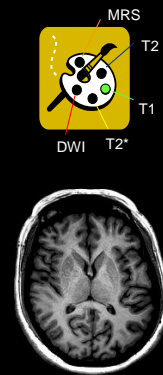
Surgical Planning

- fMRI
- Fiber tracking



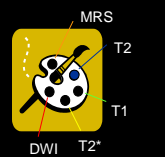
Epilepsy

- Requirements:
 - High resolution anatomy
 - IR-FSPGR
 - Coronal IR
 - T2 sensitivity
 - Multiplanar
- Surgical planning
 - MRS
 - fMRI



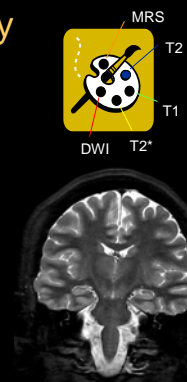
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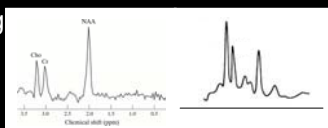
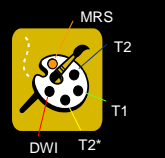
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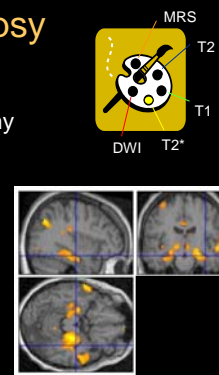
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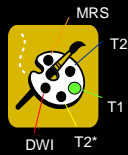
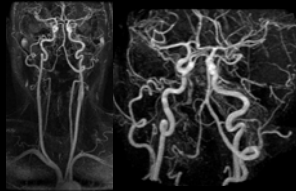
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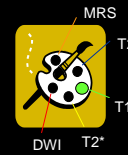
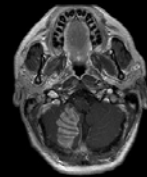
Vessels

- Great vessels
 - Atherosclerosis
 - Dissection
 - Aneurysm
 - Familial screening
 - Post-op
 - Clip
 - Coil



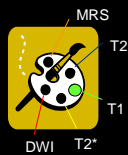
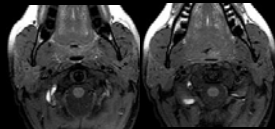
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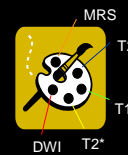
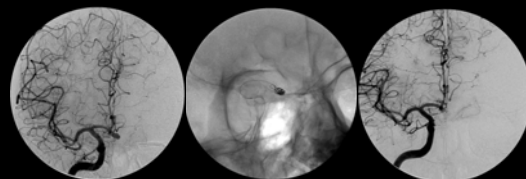
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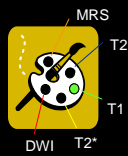
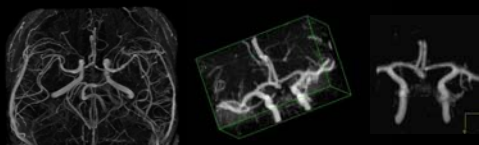
Vessels

- Post coil aneurysm



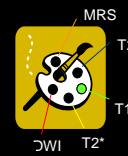
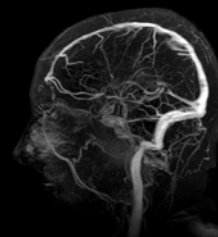
Vessels

- Post coil aneurysm



Vessels

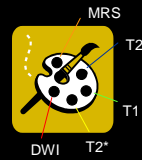
- Venography
 - Gd bolus



Infarct

- Requirements:

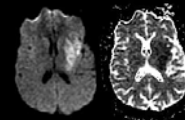
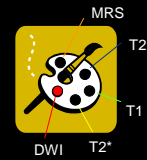
- Speed
- Penumbra imaging
- Detect Hemorrhage
- Arch to COW angiography
- BBB breakdown?



Infarct

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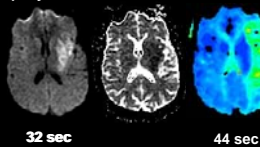


32 sec

Infarct

- Requirements:

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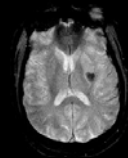
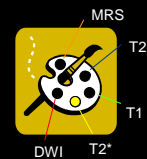
32 sec

44 sec

Infarct

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- Detect Hemorrhage
- Arch to COW angiography
- BBB breakdown?

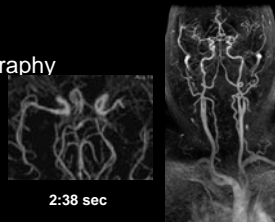


20 sec

Infarct

- Requirements:

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- Detect Hemorrhage
- Arch to COW angiography
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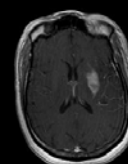
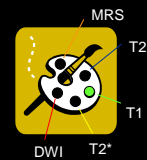


2:38 sec

Infarct

- Requirements:

- Speed
- Penumbra imaging
- Detect Hemorrhage
- Arch to COW angiography
- BBB breakdown?

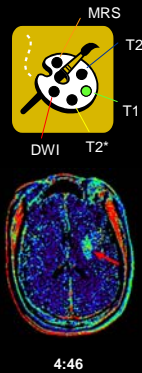


42 sec

Infarct

- Requirements:

- Speed
- Penumbra imaging
- Detect Hemorrhage
- Arch to COW angiography
- BBB breakdown?



Protocol

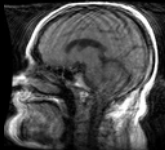
• Sag Loc (multi-planar)	35 sec
• Ax T1	35 sec
• Ax EPI-diffusion	32 sec
• Ax EPI-FLAIR	39 sec
• Ax EPI-GE (iron sequence)	20 sec
• Ax FSPGR (permeability sequence)	286 sec
• Ax EPI-perfusion (18 slices)	44 sec
• Cor ATECO MRA (Arch to COW)	158 sec
• Axial T1 FSE	35 sec

TOTAL

11 min 24 sec

Moving Patients

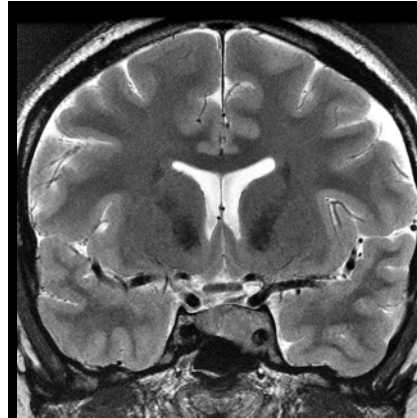
- Propeller* - periodically rotated overlapping parallel lines with enhanced reconstruction



256x194 4:48

480x480 ETL 36 3:28

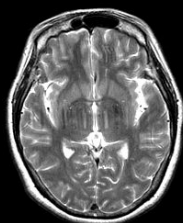
©Jim Pipe - University of Michigan.



FRFSE
TR 3800
TE 97
8:06 (5 slices)
3mm thick
FOV 18 x 18
Matrix 1024 x 1024
(176 x 176 microns)

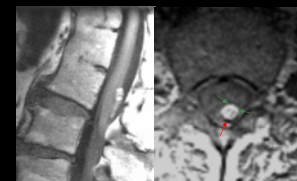
Pitfalls: Image Artifacts

- Phase artifacts
- Chemical shift
- Truncation
- Susceptibility
- EPI fat sat
- Motion



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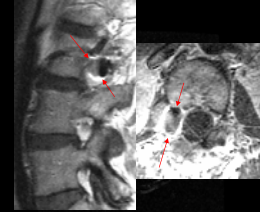
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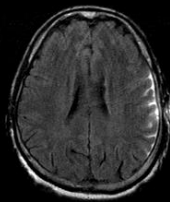
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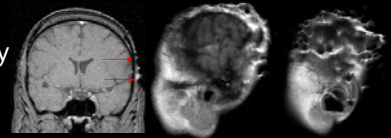
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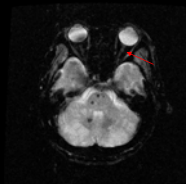
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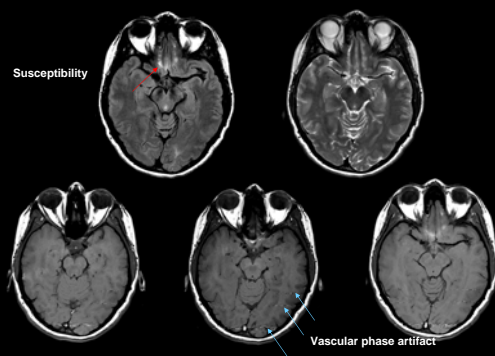


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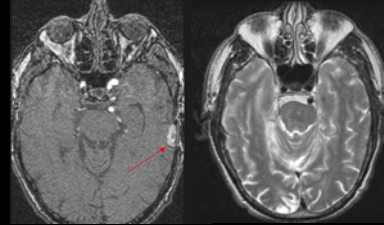
Artifacts



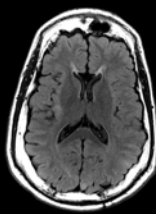
Pitfalls: Protocols

- FOV
- FLAIR inversion time
- Sequence modification “on the fly”
- Gd bolus vs non-contrast TOF MRV
- Long ETL
- DWI/ADC – T2 shine through

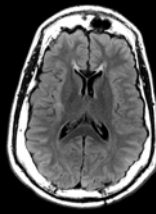
FOV Too Small



FLAIR: Improper TI

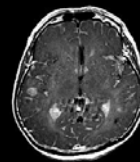


TI = 2000 msec

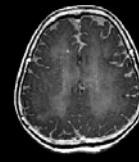


TI = 2200 msec

Sequence Modification “on the fly”



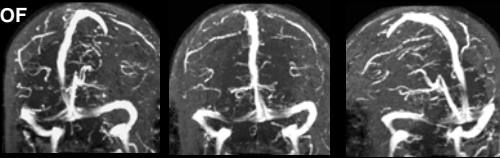
FRFSE
Post Gd++
TR = 317
TE = 11.6
ETL = 3



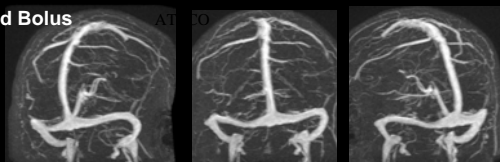
Conventional T1
Post Gd++

TOF vs Gd Bolus Venography

TOF



Gd Bolus

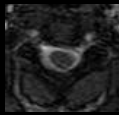


Spine

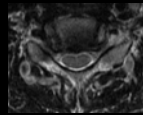
- Sagittal T1 and T2
- Axial
 - Foraminal visualization
 - Cord/CSF/disc discrimination
- Gd++
 - Cord lesions
 - Scar vs disc



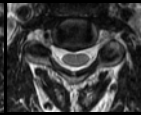
Spine



3D GRE



3D FRFSE



Summary

- Each imaging protocol should be the right mix of speed, resolution, and image quality.
- Since each user has specific needs, preferences, and types of pathology, it is difficult to recommend a standard set of protocols.
- A solution that has worked effectively at our institution is the establishment of a monthly protocol meeting composed of Rad staff, MRI techs, Vendor rep, Physicist where modified and new protocols are discussed, implemented, and then reviewed at the next meeting.
- As changes in hardware and pulse sequence technology evolve, protocol modifications can be updated and made quickly in order to maintain the state-of-the-art and maximize the return on capital investment.